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Agricultural Memorandum No. 827

Forecasting Septoria in England and Wales III

by H. Beck and N. Thompson

1. Introduction Ag Mem 801 described tests of a simple forecasting rule for Septoria, based on the number of rain days ($\geqslant$ 1 mm) in the second half of May and first half of June. The amount of disease was assumed to be the average percentage area of the second leaf affected by lesions during July. The disease data were obtained from the National Leaf Disease Survey for the years 1970 to 1975. In Ag Mem 806 it was suggested that following the establishment of the disease on the plants a period of warm weather in June or July might increase the amount of final infection. Additionally there is a possibility that the amount of disease in the previous season influences the autumn and winter carry-over and percentage infection in the following summer. The results of a consideration of these points are presented now.

2. The disease/weather relationships It was assumed that percentage leaf area infection (I) was related linearly to the number of raindays (W) in the second half of May and first half of June. The effects of temperature on the final percentage infection could not strictly be isolated from the level of infection earlier in the season: clearly some infection was required before temperature could produce an enhancement or reduction of the final disease level. This requirement was met simply by including temperature as a multiplying factor, leading to the expression

$$I = a + bw\,(1 + eT^1)$$

$$= a + bw + cWT^1 \qquad (1)$$

where a, b and c are constants to be determined by regression analysis, and T^1 is the departure from the average temperature over the period considered. It was convenient to use T^1 rather than actual temperature because values for the former were available already from Weekly Weather Notes. This was not a serious constraint on the analysis which was intended to provide a framework for description of the year-to-year variations of disease levels. T^1 was calculated for six different periods:

T^1 (1)	first half of June
T^1 (2)	second half of June
T^1 (3)	first half of July
T^1 (4)	whole of June
T^1 (5)	last half of June and first half of July
T^1 (6)	June and first half of July

The measured amount of infection in the previous season (I_{-1}) was assumed to produce a linear response in I, without any modification by temperature, but although neglect of a temperature factor here is not strictly justified it will become evident that this is not a serious limitation in the analysis. The final relation tested was

$$I = a + bw + cWT^1 + d\,I_{-1} \qquad (2)$$

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3. Analysis The infection data were expressed as regional averages, leading to too few data to calculate meaningful values for the coefficients in Eq. (2) for the individual regions. Three groupings of the data were used therefore:-

(a) 4 most susceptible regions (SW,SE,W. Mid.,Wales)
(b) 4 least susceptible regions (E.Mid., E, Yorks/Lancs,N)
(c) All 8 regions

The coefficients in Eq. (2) were evaluated using a stepwise linear multiple regression program. Variables on the right-hand side of the equation were entered in turn but were retained in the final regression formula only if the reduction in variance produced by their inclusion corresponded to an F-ratio of at least 3. This is equivalent to a significance level better than about 7%, or a partial correlation coefficient for the variable being considered greater than 0.35.

The results presented in Table 1 show that the previous year's level of infection had negligible effects on disease levels for the most susceptible group of regions. This suggests that the disease is essentially endemic in these regions, with always enough winter carry-over to provide an ample supply of innoculum each year. However, inclusion of the preceding year's infection in the regression analysis for the least susceptible region produced a useful increase in correlation. Departures from average temperatures had no value for disease prediction in these latter areas. Disease in the more susceptible regions was well correlated with temperature departures for the first half of July and this correlation was still significant when data from all regions were combined. On the other hand temperature departures for the same period for the less susceptible group produced an insignificant F-ratio in spite of being similar in sign and magnitude to those for the other regions; the apparent success of temperature in the regression for these latter regions may be a statistical accident therefore.

An alternative formulation of Eq. (2), in which the temperature departures were incorporated in an additive rather than multiplicative role, was also tested:

$$I = a + bw + cT^{1} + a\,I_{-1} \qquad (3)$$

Using data from all regions it was found as before that the temperature departures for the first half of July were the only ones correlated significantly with disease levels: the multiple correlation coefficient in this case was 0.79 compared with 0.77 obtained using Eq. (2).

The regression analysis was also carried out on the full 6 years of data by dropping I_{-1} from Eq. (2). Temperature departures in early July again produced a significant improvement in correlation for the most susceptible group (R increasing to 0.75 from 0.71), but the F-ratio associated with the inclusion of temperature had fallen to 3.2, compared with 11.3 for 1971-75, reinforcing the idea that the apparent success of this selected period was the result of no more than a sampling fluctuation. For the other group of regions, and for all regions together the temperature departure had no predictive value.

4. Conclusions No convincing evidence has been found for a significant improvement in the forecasting scheme for Septoria following the inclusion of departures from average of temperatures during June and the first half of July. The level of disease in the previous season has a measureable effect on subsequent disease in the regions least susceptible to Septoria infections. Overall correlations (generally between 0.7 and 0.8) are rather low for the scheme to be considered very successful. However, taking up a point made in Ag Mem 806, provided the forecasts are used to indicate in very broad terms the likely disease levels for areas rather than individual sites then some useful prediction value is achieved.

Any comments or suggestions on this paper should be referred to the authors.

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TABLE 1 Regression analysis based on Eq. (2)

Data Set	Variable	F-value on entry	Correl. Coeff.	Next Variable	F-value on entry	Multiple Corr. Coeff.	Next Variable	F-value on entry	Final Multiple Corr. Coeff.	S.E. of estimate	Final equation
(a) 1971-1975 SW,SE,W. Mid, Wales	W	28.8	.78	$WT^1(1)$	2.0	-	I_{-1}	0	0.78	8.6	(i)
				$WT^1(2)$	0	-		0	0.78	8.6	(i)
				$WT^1(3)$	11.3	0.88		0.2	0.88	7.8	(ii)
				$WT^1(4)$	0.5	-		0	0.78	8.6	(i)
				$WT^1(5)$	1.6	-		0	0.78	8.6	(i)
				$WT^1(6)$	1.7	-		0	0.78	8.6	(i)
(b) 1971-1975 EM, E, Yorks/ Lancs, N	W	14.8	.67	$WT^1(1)$	0.1	-	I_{-1}	3.8	0.74	6.9	(iii)
				$WT^1(2)$	0.4	-		3.8	0.74	6.9	(iii)
				$WT^1(3)$	0.1	-		3.8	0.74	6.9	(iii)
				$WT^1(4)$	0.2	-		3.8	0.74	6.9	(iii)
				$WT^1(5)$	0.1	-		3.8	0.74	6.9	(iii)
				$WT^1(6)$	0.1	-		3.8	0.74	6.9	(iii)
(c) 1971-1975 All regions	W	37.3	.70	$WT^1(1)$	0.1	-	I_{-1}	4.2	0.74	8.1	(iv)
				$WT^1(2)$	0.3	-		4.2	0.74	8.1	(iv)
				$WT^1(3)$	4.2	0.74		4.2	0.77	7.8	(v)
				$WT^1(4)$	0	-		4.2	0.74	8.1	(iv)
				$WT^1(5)$	0.7	-		4.2	0.74	8.1	(iv)
				$WT^1(6)$	0.6	-		4.2	0.74	8.1	(iv)

(i) $I = -6.5 + 2.7W$

(ii) $I = -13.7 + 3.7W + 0.29\ WT^1(3)$

(iii) $I = -8.6 + 1.9W + 0.31\ I_{-1}$

(iv) $I = -7.8 + 2.1W + 0.24\ I_{-1}$

(v) $I = 11.6 + 2.6W + 0.16WT^1(3) + 0.28\ I_{-1}$